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THE PHYSICAL CHEMISTRY OF BREAD MAKING[1]

THE art of making leavened bread has been so long perfected that the experience upon which present practise rests is now forgotten. Meanwhile the science of bread making, involving physical, chemical and physiological problems of a certain complexity, and only recently promoted by a great organized industry, has hardly kept pace with the advance of biological chemistry. But at length war time necessity has imposed new conditions, and the use of flours other than wheat has brought about changes from the best practise of the past.

It seems desirable, therefore, to review the physical and chemical processes involved in the fermentation of dough and the baking of bread, and make suggestions which may facilitate the use of wheat substitutes.

GLUTEN

When wheat flour is made into dough the proteins, after absorbing water, hold together to a much greater extent than do the proteins of any other grain. This property makes it possible to separate from the other constitutents of wheat flour the two proteins, gliadin and glutenin,[2] which are insoluble in water. The material which can in this way be washed free contains about ten per cent. of the flour[3] and includes about nine tenths of all the protein material.[4] It is called gluten.

[1] From the Wolcott Gibbs Memorial Laboratory of Harvard University, in collaboration with the Division of Food and Nutrition, Medical Department, U. S. Army.

[2] Osborn, T. B., "The Proteins of the Wheat Kernel." Washington, 1907.

[3] Bulletin 13, part 9, Division of Chemistry, United States Department of Agriculture.

[4] Jago, William, "Science and Art of Bread-making," pp. 288–303, London, 1895.

Proteins, unlike starches, combine with acids and alkalis. Such combinations differ in their properties according to the quantity of acid or alkali which they contain. Similar differences are also produced in the properties of proteins by the action of salts. Among the most important of the effects of acids, alkalis and salts upon proteins is the modification of the swelling in water, and partly as a result of this, of elasticity, tenacity and cohesiveness. Another important effect is a change in the solubility of the proteins.

As the amount of acid or alkali combined with gluten varies, the amount of water which can be absorbed varies from 2½ to 3½ times the weight of the gluten itself.[5, 6, 7] Certain salts also have an important effect upon the swelling of gluten.[8]

In spite of the fact that such phenomena are more or less similar to those which may be observed with other proteins, there are many properties of gluten which are very different from those of other known protein substances. The unique properties of gluten make possible the manufacture of good leavened bread.

DOUGH

The swollen, coherent gluten imparts to wheat-flour dough the properties of tenacity and elasticity that are peculiar to it. It permits the stretching and distending of the mass in bread-making. As a result the volume may increase four or five fold. Dough made from other grains, even though containing more protein and possessing a greater capacity to absorb water, is both less elastic and less coherent. When stretched such doughs break. The baker calls them "short."

The extent to which dough can be distended varies with the quantity and with the physical condition of the gluten. Within certain limits the baker can therefore improve the rising of dough by modifying the physical condition of gluten. Thus, for instance, increasing the acidity of dough will increase its elasticity[9] and certain salts, such as calcium sulphate, may have a similar effect.

THE FERMENTATION OF SUGAR

Bread is leavened by the formation of carbon dioxide within the dough through the fermentation of sugar by yeast. Yeast can freely utilize either cane sugar or glucose for the production of carbon dioxide. In American baking practise, where a short fermentation is usually preferred, sugar is therefore added to dough. The proper amount of sugar depends upon the conditions of the fermentation. It is, however, as the present practise of certain nations and the early history of baking prove, not necessary to add any sugar at all, for a small amount of sugar is present in flour,[10, 11] and more is slowly produced from starch during fermentation by the action of enzymes. But sugar can not be left out unless the whole practise of the baker differs from that now followed in America.

THE PRODUCTION OF CARBON DIOXIDE BY YEAST

Yeast is very sensitive to slight changes in the dough batch. For instance, activity at 30° C. (86° F.) is about twice as great as 20° C. (68° F). The production of carbon dioxide is, however, much decreased by the large quantity of salt which is added to the dough with the water, sugar and shortening. By means of this effect of salt on the activity of yeast the baker commonly controls the

5 Wood, T. B., "The Chemistry of Strength of Wheat Flour," *Jour. Agricultural Science*, Vol. 2, Part 3, pp. 267–277, 1907.

6 Wood, T. B., and Hardy, W. B., "Electrolytes and Colloids: The Physical State of Gluten," *Proceedings Roy. Soc. B*, LXXI., pp. 31–43, 1909.

7 Unpublished observations.

8 Wood, T. B., "The Chemistry of Strength of Wheat Flour," *Jour. Agricultural Science*, Vol. 2, Part 2, pp. 139–160, 1907.

9 Henderson, L. J., Fenn, W. O., Cohn, E. J., "The Influence of Electrolytes upon the Viscosity of Dough" *Journal of General Physiology.*

10 Wood, T. B., "The Chemistry of Strength of Wheat Flour," *Jour. Agricultural Science*, Vol. 2, Part 2, pp. 267–277, 1907.

11 Maurizio, *Landwirtschaftliche Jahrbücher*, XXXI., 1902.

length of fermentation. Another method is to vary the quantity of yeast.

But the rate of carbon dioxide production by yeast is also greatly influenced by the products of its own activity. During fermentation there is a continual increase in the acidity of dough and as a result, up to a certain point (reached only in very old and very acid dough), the activity of the yeast steadily becomes greater. The activity of the yeast will, nevertheless, diminish when the supply of sugar is no longer sufficient.

THE PRODUCTION OF ACID BY YEAST

The increasing acidity of dough both improves the condition of the dough and increases the production of carbon dioxide by the yeast. Accordingly, the dough rises more and more rapidly as the fermentation progresses.

The baker usually prolongs fermentation by "knocking down" the dough. By thus prolonging the process the products of the fermentation and the acidity of the dough are increased and therefore the volume of the dough, when it rises again, is greater.

THE ADDITION OF ACID TO DOUGH

The addition of such weak acids as lactic or acetic acid (vinegar) to dough has much the same effect. The amount of acid that may be added will vary with the amount of yeast and the length of fermentation. It can best be judged by determining the acidity of the baked loaf.[12] This can be done by judging the color when a few drops of methyl red are added to a slice of bread. The amount of acid which can favorably be added in ordinary bread making is discussed below in connection with the prevention of rope. It must be remembered that the desirable amount of acid varies with the quantity of yeast, with the quality of the wheat flour, with the quantity and variety of substitute and with the habits of the baker.

In the first place the desirable length of the fermentation is determined by the acidity of the dough. Increase in acidity increases the activity of the yeast and shortens the fermentation. Consequently the amount of sugar required by the yeast is diminished.[13] Beside the rate of carbon dioxide production of the yeast within the dough, the tenacity and elasticity of the dough, and the escape of gas from the dough are dependent upon acidity. Experience in this and other laboratories has shown that the best acidity for the baking of bread is indicated by the turning of methyl red from orange to red.[14, 15, 16] *In sum, the acidity of the dough at the time of baking seems to be the most important variable factor in bread making.*

THE ESCAPE OF GAS FROM THE DOUGH

The volume of the baked loaf is not completely determined by the volume of the risen dough. For not all of the carbon dioxide produced is retained within the dough: a large part escapes into the air. As a dough expands more and more the loss of gas increases, because the surface of a distended dough becomes greater, while the walls of the batch grow thin and more leaky. When, during the last rise, loss of gas from the dough becomes nearly as great as the production of carbon dioxide, the loaf *must* be baked regardless of its size. But the more tenacious and elastic the dough, the larger will be its volume before the losses from the batch reach this point. The "age" or "ripeness" of the dough is always best determined by the baker who through long practise has learned to judge it accurately.

BAKING

It has been suggested that dough must be baked before the loss of gas is equal to the

[12] Henderson, L. J., "The Prevention of Rope in Bread," Science, N. S., Vol. 48, No. 1236, pp. 247-248, 1918.

[13] Unpublished observations.

[14] Cohn, E. J., Cathcart, P. H., and Henderson, L. J., "The Measurement of the Acidity of Bread," *Jour. Biological Chemistry*, 1918.

[15] Jessen-Hansen, *Comptes Rendus Trav. Lab. Carlsberg*, Vol. 5, No. 10, 1911.

[16] Landenberger, L. L., "Barley Bread Optimum Reaction and Salt Effect," Science, N. S., Vol. 48, No. 1237, pp. 269-270, 1918.

production of carbon dioxide, or, in other words, before the rise ceases. Such doughs are "ripe" for the oven. The baker says their "proof" is complete.

The less elastic and tenacious doughs of the present emergency have little "spring" in the oven and if ripe are very liable to fall during the early stages of the baking. To guard against this it is a common practise to shorten the fermentation, which involves baking at a lower acidity.

"Overproved" doughs usually fall in the oven before the crust is formed by drying and coagulation of the proteins of the dough. In them the loss of carbon dioxide is not even compensated by the expansion of the gas at the higher temperature of the oven. Doughs that are not "ripe" for the oven are in the opposite condition and are termed "underproved." The leakage of carbon dioxide from such doughs is not sufficient to permit the escape of the expanded gas and the loaf is "ripped."

WHEAT SUBSTITUTES

Although corn, barley and wheat flour contain nearly equal amounts of similar proteins, the properties of their doughs are markedly different. Rye is more tenacious than barley, and barley than corn, but in comparison with doughs made of wheat flour all others are "short." They do not hold together and are not distensible. Therefore—with the possible exception of rye—they can not retain the carbon dioxide that is produced within them. To whatever extent such flours are substituted for wheat the same effects are observed in due proportion. For the "body" of the dough is supplied by the wheat gluten alone. The degree to which the dough can be distended therefore depends upon the amount and the hydration of the gluten. But in the presence of substitutes the hydration of gluten is complicated in two ways: first because water is absorbed by the proteins of corn and of barley as well as by the proteins of wheat, but nevertheless without the resulting elasticity;[17] secondly because corn and barley combine with larger quantities of acid than does wheat.[18] The increasing acidity of the fermenting dough is thus partially neutralized. As a result neither the activity of the yeast nor the elasticity of the dough increases so rapidly in the presence of substitutes. If the smaller amount of gluten that is present is to swell to the same extent as in ordinary bread the same acidity must be reached. Therefore if the amount of yeast or the length of the fermentation is not to be increased, acid must be added to the dough.

But if the volume of the loaf is in this way increased, other dangers beset the baker when using a high percentage of substitute flours, for the leakage of carbon dioxide from the dough is also increased. As above mentioned the dough has little "spring" and falls more easily in the oven. This is another reason why the cautious baker has made his bread less acid during war time. He prefers baking dough that is "younger." The frequent occurrence of "ripped" bread is in this way accounted for.

Moreover, the popularity of starch in the larger bake shops of the country during the last year, and the facility with which it was used, depend upon the fact that unlike all flours, starch absorbs only about half its weight of water and combines with acid to an inappreciable extent.

SERUM PROTEINS

Although skillful control of the fermentation and of the acidity of dough (and sometimes the addition of salts like calcium sulphate) can improve leavened bread of any kind, it can not make up for the lack of gluten in wheat substitutes. Therefore, when wheat substitutes are employed it is desirable to add a small amount of a substitute for gluten.

The proteins of serum are such a substitute. The addition to flour containing 20 to 25 per cent. wheat substitutes of two or three per cent. of dry powdered serum (which must be

[17] Unpublished observations.

[18] Unpublished observations.

freely soluble)[19] yields a dough quite as easy to handle as that produced from pure wheat flour. Such a dough does not, like ordinary doughs containing substitutes, easily become "overproved." The loaves do not fall in the oven, for the serum proteins decrease the leakage of carbon dioxide from the dough.[20] The danger of the loss of a whole batch from excessive fermentation is therefore minimized.

The use of serum proteins in this way materially lessens the very real difficulties which now exist. Moreover the resulting loaf is larger and more elastic, of better color and texture, and in all respects superior to loaves containing equal amounts of wheat substitutes but lacking serum. If it is inferior to bread made of pure wheat flour, it possesses certain important qualities of its own, and its use seems to be in all respects quite unexceptionable.

ROPE

Ropy bread is produced by the action of certain microorganisms whose spores survive the heat of the oven and later, when the conditions are favorable, attack the center of the loaf. At a temperature of about 26° C. (80° F.) their growth is rapid. For this reason epidemics of rope occur in summer. The principle organisms which cause rope belong to the *B. mesentericus* group.

Another condition which is necessary for the development of the rope organism is low acidity.[21] Bread which is sufficiently acid is quite immune. It is therefore possible absolutely to prevent rope by sufficiently increasing the acidity of dough. It has been found that the degree of acidity which is otherwise most favorable in ordinary bread making, at least as practised both in America[14, 16] and in Denmark[15] is sufficient for this purpose. This acidity is indicated by a full red color when a few drops of a solution (0.02 per cent. in 60 per cent. alcohol) of the indicator methyl red are placed upon a slice of bread. Bread should be adjusted to this acidity, especially when there is danger of an epidemic of rope. This is best done by the addition of increasing amounts of acid to the dough of successive batches until the baked loaf gives the desired color. Generally the right amount of lactic acid is between one and two pounds of the commercial product (22 per cent.–25 per cent.) per barrel of flour. (This corresponds to 1.25 c.c. normal lactic acid in 100 g. flour.)

It has been pointed out that wheat substitutes usually combine with more acid than wheat flour itself. In this way they neutralize the acidity of the dough and as a result the greater the amount of substitute the greater is the amount of acid that must be added to bring bread to the acidity indicated by a red color of methyl red. The preference of the baker for "young" doughs and the greater capacity of the substitutes to neutralize acids is the reason why rope has caused so much trouble during war time.

We are indebted to the Carnegie Institution of Washington and to Professor Theodore W. Richards for the use of much valuable and indispensable apparatus, without which our researches could hardly have been carried out. It is a great pleasure to express our thanks for this aid.

E. J. Cohn,
L. J. Henderson

[19] Burrows, G. H., and Cohn, E. J., "A Quantitative Study of the Evaporation of Serum Proteins," *Jour. Biological Chemistry*, 1918.

[20] Unpublished observations.

[21] Cohn, E. J., Wolbach, S. B., and Henderson, L. J., "The Control of Rope," *Jour. of General Physiology*, Vol. 1, No. 2, 1918.

INDUSTRIAL RESEARCH AND NATIONAL WELFARE[1]

At the outbreak of the war the average statesman of the Allied powers was but little concerned with the interest of research. Necessity, however, soon opened his eyes. He began to perceive the enormous advantages derived by Germany from the utilization of sci-

[1] From an address delivered by Dr. George E. Hale under the auspices of Engineering Foundation in the Engineering Societies Building, New York, May 28, 1918.

ence, and sought to offset them by the creation of appropriate agencies. Thus arose throughout the British Empire a group of councils for scientific and industrial research. The first of these was established in England by an order in council issued in 1915. Subsequently, Canada, Australia and South Africa followed the example of the mother country, and New Zealand proposes to do likewise. The world-wide movement swept across the empire, and its benefits will be felt in every country under the British flag. A similar awakening was experienced in France and Italy, but in both of these countries the pressure of the war concentrated attention for the moment upon military problems. At present, the needs of industry are also under consideration, and research organizations are being developed to meet them.

Without entering here into a detailed discussion of these councils, we may mention certain typical illustrations of their activities from the report of the British Advisory Council for Scientific and Industrial Research for the year 1916–17. In this period it devoted itself mainly to the organization of industrial research, partly because of the prime importance of stimulating and fixing the interest of manufacture in the development of industry through research, and partly because the effect of the war has been to render industrial leaders more susceptible than ever before to the growth of new ideas. In pure science, on the contrary, the war has seriously affected the prosecution of research, because so many investigators have been drawn into military and industrial activities. Thus, while the advisory council strongly emphasizes the fundamental importance of pure science, it has been forced to postpone its activities in this field until the arrival of more favorable conditions.

Research for the development of the industries may be conducted in several different ways. In this country a stimulating example has been set by such great corporations as the American Telephone and Telegraph Company, the General Electric Company, the Eastman Kodak Company, the Dupont Companies, and the Westinghouse Electric Company, which have established large research laboratories.

The value of this example has been enhanced by the remarkable success achieved by these laboratories in matters affecting public welfare, such as the reduction in cost of electric lighting caused by the development of the Mazda lamp and the possibility of transcontinental telephony, not to mention the latest advances in the field of wireless telephony.

Self-interest will sooner or later induce many other corporations to adopt similar methods of improving their products, but the heavy expense of establishing independent research laboratories will sometimes prove an insurmountable obstacle. Other means must then be resorted to. A useful example is that afforded by the National Canners' Association, which has established a central research laboratory in Washington, where any member of the association can send his problems for solution and where extensive investigations, the results of which are important to the entire industry, are also conducted.

The British Advisory Council, aided by a government appropriation of one million pounds, is actively promoting the organization of trade research associations for the mutual benefit of the members of the great industries. Thus a provisional committee representative of the British cotton industry has proposed the establishment of a cooperative association for research in cotton, to include in its membership cotton spinning, doubling the thread making firms, cloth, lace and hosiery manufacturers, bleachers, dyers, printers and finishers, which will conduct researches extending from the study of the cotton plant to the "finishing" of the manufactured article. So long ago as 1835 Baine wrote in his "History of the Cotton Manufacture": "The manufactory, the laboratory and the study of the natural philosopher, are in close practical conjunction; without the aid of science, the arts would be contemptible; without practical application, science would consist only of barren theories, which men

would have no motive to pursue." This spirit, clearly shown in the early cotton industry, is now to be revived for the common benefit.

The woolen and worsted manufacturers of Great Britain are also drafting the constitution of a research association, and the Irish flax spinners and weavers are about to do likewise. Research associations will be established by the Scottish shale oil industry and the photographic manufacturers, while various other British industries are looking in the same direction. Thus a national movement for research, directly resulting from the war, has already made marked headway. The research councils in various parts of the British Empire, actuated by the same spirit, are rapidly extending the advantages which an appreciation of the national importance of research will afford.

The National Research Council, aided and supported by the Engineering Foundation, is just entering upon an extensive campaign for the promotion of industrial research. In addition to a strong active committee, comprising the heads of leading industrial laboratories and others prominently identified with scientific methods of developing American industries, an advisory committee has been formed to back the movement. This already comprises the following gentlemen: Honorable Elihu Root; Mr. Theodore N. Vail, president of the American Telephone and Telegraph Company; Dr. Henry S. Pritchett, president of the Carnegie Foundation for the Advancement of Teaching; Mr. Edwin Wilbur Rice, Jr., president of the General Electric Company; Mr. George Eastman, president of the Eastman Kodak Company; Mr. Pierre S. duPont, president of the E. I. duPont de Nemours Powder Company; Mr. A. W. Mellon, founder of the Mellon Institute for Industrial Research; Judge E. H. Gary, president of the United States Steel Corporation; Mr. Cleveland H. Dodge, of the Phelps-Dodge Corporation, and Mr. Ambrose Swasey, of The Warner and Swasey Company.

We are indeed fortunate to have the aid of men whose experience and standing are so certain to command public recognition of the claims of scientific and industrial research.

Science is in the air, keen competition is in prospect, and the industries are more favorably inclined than ever before to the widespread use of research methods. Their greatest leaders, moreover, are unanimous in their appreciation of the necessity of promoting research for the sake of advancing knowledge, as well as for immediate commercial advantages. Only thus can the most fundamental and unexpected advances be rendered possible, and continued progress in all directions assured.

GEORGE SCHRADER MATHERS

CAPTAIN GEORGE SCHRADER MATHERS, M.C., U. S. Army, a member of the staff of the McCormick Institute for Infectious Diseases, Chicago, died October 5, 1918, at the age of thirty-one.

Captain Mathers took his college work in the University of Texas and the University of Chicago, and received his medical degree from Rush Medical College in affiliation with the University of Chicago in 1913. Having served one year and one half as interne in the Cook County Hospital he began work in the McCormick Institute under a grant from the Fenger Memorial Fund, but before long he became associated fully with the institute. During the three and one half years of this association he accomplished much fruitful work and published important papers or lobar pneumonia, epidemic poliomyelitis, acute respiratory infections in man and in the horse, and on epidemic meningitis. He demonstrated that a streptococcus-like microorganism occurs apparently constantly in the central nervous system in persons that have died from epidemic poliomyelitis. Early last spring he was commissioned as first lieutenant and placed in charge of the laboratory of the embarkation hospital at Camp Stuart. In May he was promoted to captain and given charge of the laboratory of the base hospital at Camp Meade. He gave himself completely to his work. In the course of his duties and while intensely

engaged in a study of the bacteriology of influenza he was stricken and died with pneumonia in a few days.

Captain Mathers was a fine, lofty-minded, lovable young man, of rare enthusiasm for work, and a remarkable efficiency. He had committed himself to research and his early death is a great loss to medicine.

LUDVIG HEKTOEN

ARTEMAS MARTIN

DR. ARTEMAS MARTIN, of the U. S. Coast and Geodetic Survey, died on November 7, 1918, after an illness of two weeks, in the eight-fourth year of his life. He was born on a farm in Steuben County, New York, on August 3, 1835. Four winters in the schools of Venango County, Pennsylvania, comprised all his schooling. Wood-chopping, oil-well drilling and farming—with four winters as a district teacher—made up his work until the age of fifty. The little leisure afforded by such work was devoted to the study of mathematics.

Early in life he began contributing problems and solutions to various magazines. In 1877, while engaged in market gardening for a livelihood, he began the editing and publishing of the *Mathematical Visitor* and in 1882 he followed this up with the *Mathematical Magazine*. Not only did he do the editing and publishing of these magazines, but for financial reasons was compelled to do the type setting also. That he did this well is evidenced by the character of the mathematical typography of his journals.

Aside from articles in his own magazines, he contributed a large number of papers to various mathematical journals here and abroad. His writings dealt chiefly with properties of triangles, logarithums, properties of numbers, diophantine analysis, probability and elliptic integrals. He was an authority on early mathematical text-books and collaborated with Dr. Greenwood in the "Notes on the History of American Text-Books on Arithmetic."

Dr. Martin's mathematical abilities received wide recognition. In 1877, Yale conferred upon him the honorary degree of A.M., Rutgers honored him with a Ph.D., in 1882, and in 1885 Hillsdale made him an LL.D. Numerous learned societies, both here and abroad, honored him with membership.

In 1885, Dr. Martin was appointed librarian of the U. S. Coast and Geodetic Survey, where his wide knowledge of mathematics made him of great service. In 1898 he was made computer in the Division of Tides, which place he held until his death.

Personally, he was a man of very prepossessing appearance. Of simple tastes and exhibiting few of the limitations of the pioneer period through which he passed the first fifty years of his life, he exemplified most of its robust virtues. Fond of home life and children he denied himself marriage that he might care for his parents and sisters. Traveling scarcely at all, he was well known to American mathematicians of the previous generation who found him an agreeable and companionable man.

Dr. Martin's memory is to be fittingly perpetuated in the Artemas Martin Library of the American University at Washington, D. C. This library, consisting principally of mathematical works, and given by Dr. Martin to the American University shortly before his death, was considered one of the finest private collections in America. At the same university there is also to be an Artemas Martin Lectureship in mathematics and physics, endowed by Dr. Martin.

SCIENTIFIC EVENTS

THE BEQUESTS OF MRS. SAGE

THE will of Mrs. Margaret Olivia Sage, disposes of an estate estimated at $50,000,000, of which more than $40,000,000 is to be distributed among charitable, educational and religious institutions. It is said that since the death of her husband, Mrs. Sage had given between $35,000,000 and $40,000,000 to various institutions and charities, using part of the principal, as well as the income, of the Sage estate in these benefactions.

The estate is divided into fifty-two equal parts for convenience in distributing the residue among the various charities named in the instrument. Each of these parts is valued at approximately $800,000.

The will contains the following clause relating to these legacies: "It is my desire that each religious, educational and charitable corporation, which may receive a share of my residuary estate shall use the whole or part of such legacy received by it for some purpose which will commemorate the name of my husband, but I simply express this as a desire and do not impose it as a condition on my gift." Certain sums given by Mrs. Sage in her lifetime to institutions and organizations are to be deducted from the amounts to be distributed from the residue, which is to be divided as follows:

Russell Sage Foundation, $5,600,000; Troy Female Seminary, Woman's Hospital in the state of New York, Board of Home Missions of the Presbyterian Church of America (woman's executive committee), Woman's Board of Foreign Missions of the Presbyterian Church, New York City Mission and Tract Society, American Bible Society, Children's Aid Society, Charity Organization Society, $1,600,000; Presbyterian Board of Relief for Disabled Ministers, $800,000; Metropolitan Museum of Art and The American Museum of Natural History, $1,600,000 each; New York Botanical Garden, New York Zoological Society, New York Public Library, Troy Polytechnic Institute, Union College, Schenectady, $800,000 each; Syracuse University, $1,600,000; Hamilton College, Clinton, N. Y., New York University, Yale University, Amherst College, Williams College, Dartmouth College, Princeton University, Barnard College, Bryn Mawr College, Vassar College, Smith College, Wellesley College, Tuskegee Normal and Industrial Institute, New York Infirmary for Women and Children, Presbyterian Hospital in the City of New York, State Charities Aid Association and Hampton Institute, $800,000 each.

The will then gives the following specific legacies to public institutions:

Troy Female Seminary, $50,000; Association for the Relief of Respectable Aged Indigent Females in the City of New York, $125,000; Woman's Hospital in the State of New York, $50,000; Board of Home Missions of the Presbyterian Church of the United States of America (Woman's Executive Committee of Home Missions), $25,000; Woman's Board of Foreign Missions of the Presbyterian Church, $25,000; New York City Mission and Tract Society (Woman's Board), $20,000; New York Female Auxiliary Bible Society, $10,000; Children's Aid Society of the City of New York, $10,000; Charity Organization Society of the City of New York, $20,000; First Presbyterian Church of Syracuse, $10,000; First Presbyterian Church at Sag Harbor, $10,000; Society for the Relief of Half Orphan and Destitute Children of the City of New York, $25,000; New York Institution for the Deaf and Dumb, $25,000; Home for the Friendless, $100,000; New York Exchange for Women's Work, $25,000; Woman's National Sabbath Alliance, $25,000; Ladies' Christian Union of the City of New York, $100,000; Working Women's Protective Union, $10,000; Servants of Relief for Incurable Cancer, $25,000; Salvation Army, $25,000; Park College, $100,000; Idaho Industrial Institute, $200,000; Old Ladies' Home at Syracuse, $25,000; Northfield Schools (Northfield Seminary and Mount Hermon Boys' School), $100,000; Middlebury College, $100,000; Rutgers College, $100,000; Y. M. C. A. of the City of New York, $100,000; Y. W. C. A. of the City of New York, $100,000; Mount Sinai Hospital, $100,000; Syracuse University, $100,000; Hampton Institute, $100,000.

INTERNATIONAL SCIENTIFIC ORGANIZATION

THE following statement has been adopted unanimously by the Inter-Allied Conference on the future of International Organization in Science, which met at Burlington House under the auspices of the Royal Society on October 9. It is intended to serve as a preamble to a number of resolutions, dealing with the withdrawal of the Allied nations from existing international associations and the formation of new ones to take their place. The confirmation of the academies represented at the Conference is required before the text of the resolutions can be made public:

When more than four years ago the outbreak of war divided Europe into hostile camps, men of science were still able to hope that the conclusion of peace would join at once the broken threads; and that the present enemies might then once more be able to meet in friendly conference, uniting their efforts to advance the interests of science. For ever since the revival of learning in the Middle Ages, the

prosecution of knowledge has formed a bond strong enough to resist the strain of national antagonism. And this bond was strengthened during the latter part of the last century, when branches of science developed requiring for their study the cooperation of all the civilized nations of the world. International associations and conferences rapidly multiplied, and the friendly intercourse between the learned representatives of different countries grew more intimate, in spite of their political differences, which were admitted but not insisted upon.

In former times, war frequently interrupted the cooperation of individuals without destroying the mutual esteem based on the recognition of intellectual achievements; peace then soon effaced the scars of a strife that was ended. If to-day the representatives of the scientific academies of the Allied nations are forced to declare that they will not be able to resume personal relations in scientific matters with their enemies until the Central Powers can be readmitted into the concert of civilized nations, they do so with a full sense of responsibility; and they feel bound to record the reasons which have led them to this decision.

Civilization has imposed restrictions on the conduct of nations which are intended to serve the interests of humanity and to maintain a high standard of honor. Such are the recognition of the sanctity of treaties—especially those designed to apply to a state of war—and the avoidance of unnecessary cruelties inflicted on civilians. In both these respects the Central Powers have broken the ordinances of civilization, disregarding all conventions and unbridling the worst passions which the ferocity of war engenders. War is necessarily full of cruelties: individual acts of barbarity can not be avoided and have to be borne. It is not of these we speak, but of the organized horrors encouraged and initiated from above with the sole object of terrorizing unoffending communities. The wanton destruction of property, the murders and outrages on land and sea, the sinking of hospital ships, the insults and tortures inflicted on prisoners of war, have left a stain on the history of the guilty nations which can not be removed by mere compensation of the material damage inflicted. In order to restore the confidence, without which no scientific intercourse can be fruitful, the Central Powers must renounce the political methods which have led to the atrocities that have shocked the civilized world.

The following delegates were expected to attend the Conference, representing different nations and academies:

Belgium.—Major Lecomte, director of the Royal Observatory of Belgium; M. Massart, professor of botany at the University of Brussels; Professeur de la Vallée Poussin.

France.—B. Baillaud, director of the Observatory of Paris; G. Bigourdan, astronomer at the Observatory of Paris; A. Haller, professor of organic chemistry at the Sorbonne; M. Lacroix, secretary of the Académie des Sciences, professor of mineralogy at the Sorbonne; Ch. Lallemand, director of the Trigonometrical Survey; Ch. Monreu, professor of pharmaceutical chemistry at the Ecole Supérieure; Emile Picard, secretary of the Académie des Sciences, professor of mathematics at the Sorbonne.

Italy.—Vito Volterra, professor of mathematical physics at the University of Rome, member of the Italian Senate.

Japan.—Joji Sakurai, professor of chemistry at the University of Tokyo; Aikitsu Tanakadate, late professor of physics at the University of Tokyo.

Portugal.—Professor Braamkamp Freire, president of the Academy of Science, Lisbon.

Serbia.—Bogdan Popovitch, professor of literature and rhetoric at the University of Belgrade; Dr. Zonjovitch, president of the Royal Academy of Belgrade.

United States.—H. A. Bumstead, professor of physics at Yale University; Colonel J. J. Carty, chief engineer of the American Telegraph and Telephone Company; W. J. Durand, professor of mechanical engineering at Stanford University; S. Flexner, director of the Rockefeller Institute; G. E. Hale, director of the Mount Wilson Observatory, A. A. Noyes, professor of chemistry at the Massachusetts Institute of Technology.

THE HARVEY SOCIETY

At a meeting of the Harvey Society held during September the following officers were elected:

President—Dr. Graham Lusk.
Vice-president—Dr. Rufus Cole.
Secretary—Dr. Karl M. Vogel.
Treasurer—Dr. F. H. Pike.
Other members of the Council—Dr. John Auer, Dr. James W. Jobling, Dr. Frederic S. Lee.

It was decided at this meeting that the number of lectures to be given during the winter of 1918–19 should not exceed six; that the lectures of last winter and this winter be incorporated together in one volume; and that the members of the society be charged dues

for one year only to cover the two years of activity. Following the policy of a year ago, the lectures to be given during this season are to be related to problems of the war.

The first lecture has already been given by Dr. E. K. Dunham. Two lectures which were arranged to be held, one by Dr. Stewart Paton on the "Psychology of the Aviator"; the other by Dr. Alonzo Taylor on the "World's Food Situation," have been postponed on account of the departure of these men for Europe. Lectures, however, have been provisionally arranged as follows:

January 11, Colonel Eugene R. Whitemore, "Infectious Diseases in the Army."

January 25, Dr. R. M. Yerkes, "Psychological Examination of the Soldier."

February 8, Dr. Yandell Henderson, "Physiology of the Aviator."

March 1, Dr. Frederic S. Lee, "Industrial Fatigue."

March 15, Colonel F. P. Underhill, "War Gases."

THE AMERICAN SOCIETY OF NATURALISTS

THE American Society of Naturalists, in affiliation with the Botanical Society of America and the American Society of Zoologists, will hold its thirty-sixth annual meeting at Baltimore, under the auspices of Johns Hopkins University, on Saturday, December 28, 1918.

The Botanical Society of America will place the genetical papers of its program on Friday morning, December 27, and the American Society of Zoologists will group its genetical papers in a program for Friday afternoon. By this arrangement there will be sessions of interest to the members of the American Society of Naturalists on the day preceding the meetings of the society.

The American Society of Naturalists will offer, beginning Saturday morning, December 28, a program to which members of the society are invited to contribute papers.

The customary symposium of the Naturalists will this year be omitted. Well developed plans of the program committee were disarranged by conditions of the times at a date too late for readjustments.

The Naturalists' dinner, in which members of the affiliated societies are invited to participate, will be held on the evening of Saturday. At the close of the dinner Vernon L. Kellogg will talk on "The German philosophy of war."

Titles of papers offered by members of the society, with estimated length of delivery and statement of lantern or chart requirements, must be in the hands of the secretary by December 1. It is desired that papers be short and it should be remembered that the interests of the Naturalists are primarily on problems of organic evolution. The papers on the program will in general be arranged in order of the receipt of title except that papers on similar subjects may be grouped.

Attention is called to the change in the constitution by which a nomination for membership must now remain in the hands of the executive committee for at least one year before action can be taken upon it. Therefore, nominations to receive attention in 1919 must reach the secretary by December 31, 1918. Blank forms for nominations may be obtained from the Secretary.

Headquarters of the Naturalists will be at the Hotel Rennert, Liberty and Saratoga Streets. Members are advised to make early reservations. A list of boarding houses will be found at Registration Headquarters of the American Association for the Advancement of Science

BRADLEY M. DAVIS,
Secretary

STATISTICAL DIVISION,
FOOD ADMINISTRATION,
WASHINGTON, D. C.

THE BALTIMORE MEETINGS OF SECTION F (ZOOLOGY) OF THE AMERICAN ASSOCIATION

THE coming meetings of Section F of the American Association for the Advancement of Science will be held at Baltimore in connection with those of the American Society of Zoologists on December 26, 27 and 28.

The address of Professor Herbert Osborn, of Ohio State University, the retiring vice-president, will probably be given Thursday afternoon, on the subject of zoological trends and values in relation to education.

A conference has been arranged between government and laboratory zoologists for the purpose of securing closer cooperation between the two groups. The Bureaus of Entomology, Fisheries, Animal Industry and the Biological Survey will present papers giving their needs and plans that can be furthered by such cooperation. The discussion will be led by Professors C. A. Kofoid, C. E. McClung, J. G. Needham and H. B. Ward. Through the kindness of the American Naturalists this conference will be held on Saturday afternoon, December 28.

The Headquarters hotel for Section F will be the Hotel Rennert, Liberty and Saratoga Streets. The association is preparing a list of boarding and rooming houses. This list may be consulted at registration headquarters.

The Biologists' smoker will be held following the opening exercises of the association on the evening of December 26, in the Hotel Rennert. The Naturalists' dinner is on Saturday evening.

As usual when meeting with the American Society of Zoologists, the program is in the hands of the latter society. Papers accompanied by abstracts of not more than 250 words will be accepted for the program up to December 1 as in other years. *These should not be sent to Captain Caswell Grave but to the acting secretary.*

W. C. Allee,
Acting Secretary, Section F,
Acting Secretary, American Society of Zoologists
Lake Forest College,
Lake Forest, Illinois

SCIENTIFIC NOTES AND NEWS

Dr. Charles R. Van Hise, president of the University of Wisconsin and eminent as a geologist, died on November 19, at the age of sixty-one years.

At the request of the board of regents of the University of Nebraska, the War Department has permitted Major Samuel Avery, chief of the University Relations Branch, Chemical Warfare Service, to resign his commission, in order to resume his duties as chancellor of the university, on December 1. Major Victor Lenher, in addition to his other duties in the Relations Section, now takes charge of the work relinquished.

Dr. William N. Berg, of the Pathological Division, Bureau of Animal Industry, Washington, D. C., has been appointed captain in the Sanitary Corps, with orders to proceed to the Yale Army Laboratory School, New Haven, Conn.

Dr. Alonzo E. Taylor has been called abroad in the interest of the Food Administration.

Professor H. Gideon Wells, of the University of Chicago and director of the Otho S. A. Sprague Memorial Institute, left Chicago on October 30 for special medical work under the auspices of the Red Cross organization in Roumania and Serbia. Dr. Wells has already spent several months in Roumania on a similar mission.

L. E. Call, professor of agronomy in the Kansas State Agricultural College, has been invited to go to France to become specialist in grain crops for the army overseas educational commission. The commission is to have charge of all educational work overseas among American soldiers during the war and during demobilization.

R. E. Tulloss, Ph.D. (Harvard, '18), has completed a year's work as consulting psychologist at the U. S. Naval Radio School, Cambridge, Mass. With the use of laboratory apparatus and technique, study has been made of the progress of some hundreds of students of radio telegraphy. Dr. Tulloss and Lieutenant W. E. Snyder, director of education at the Cambridge School, have collaborated in the preparation of a text-book for radio operating instruction.

Professor H. F. Moore, of the engineering experiment station of the university of Illinois, has been appointed by the National Research Council chairman of the committee to investigate the fatigue phenomena of metals.

Frederick Starr, associate professor of anthropology in the University of Chicago, is

now in Guatemala, where he is conducting special researches in his field.

MR. FRANK C. BAKER, curator of the Museum of Natural History, and Professor Frank Smith, of the department of zoology, University of Illinois, have been engaged during the past summer in making a mussel survey of the upper waters of the Big Vermilion River, with special reference to the effect of the sewage from Champaign and Urbana on the mussel fauna of the Salt Fork of the Vermilion River. Results have been obtained bearing on both the distribution of the river mussels in this stream and the effect of the sewage on this distribution.

MR. H. A. NOYES, research associate in horticultural chemistry and bacteriology at the Purdue Agricultural Experiment Station, has resigned to accept an industrial fellowship with the Mellon Institute, University of Pittsburgh.

DR. RHODA ERDMANN has returned to New Haven, her present address being 67 Trumbull Street.

PROFESSOR SELSKAR M. GUNN, one of the associate directors of the American Commission for the Prevention of Tuberculosis in France (the Rockefeller Foundation), gave a lecture, illustrated by lantern slides, at the annual meeting of the National Association for the Prevention of Consumption and other Forms of Tuberculosis, at London on October 29.

DR. JAMES JACKSON PUTNAM, emeritus professor of diseases of the nervous system in the Harvard Medical School, died at his home in Boston on the fourth instant, in the seventy-third year of his age.

DR. P. H. MELL, of Atlanta, Ga., died on October 12 at the home of his brother-in-law, Mr. V. M. Fleming, of arteriosclerosis. He was born in Athens, Ga., in 1850, the son of Dr. P. H. Mell, chancellor of the University of Georgia. He was for many years professor of natural science in the Alabama College and afterwards president of Clemson College, S. C. Since he retired from active college work he has been treasurer of the Home Mission Board of the Southern Baptist Convention.

UNIVERSITY AND EDUCATIONAL NEWS

DR. CHARLES LOCKE SCUDDER has been appointed acting dean of the Harvard Graduate School of Medicine.

PROFESSOR FREDERICK SLOCUM, who has been on leave of absence for a year in the service of the United States Shipping Board, training men for service upon the Merchant Marine, has resigned his position as director of the Van Vleck Observatory and professor of astronomy at Wesleyan University in order to become professor of navigation and director of the School of Navigation in Brown University. Professor Burton H. Camp, of the mathematics department, has been appointed acting director of the Van Vleck Observatory.

THE department of physiology of the University of Rochester has secured the services of Dr. M. H. Givens as assistant professor of biochemistry, and of Dr. Harry B. McClugage as instructor. The department is cooperating with the Division of Food and Nutrition of the Medical Department, U. S. Army, and with the Department of Agriculture, in the investigation of the antiscorbutic properties of dehydrated vegetables and fruits.

MURRAY P. HOROWITZ, instructor in the department of biology and public health of the Massachusetts Institute of Technology, has also been appointed instructor in advanced bacteriology in the botany department of Wellesley College.

PROFESSOR C. A. BARNHART, formerly of Carthage College, has been appointed professor of mathematics in the University of New Mexico.

BURNS OSCAR SEVERSON, formerly at the Pennsylvania State College, has accepted the position of associate professor in animal breeding at the Kansas State Agricultural College. This position was left vacant through the resignation of Captain E. N. Wentworth, who is now in France.

DISCUSSION AND CORRESPONDANCE

BOTANY AFTER THE WAR

There has been running in the issues of the *New Phytologist,* beginning in December, 1917, a discussion on "The Reconstruction of Elementary Botanical Teaching," which all American botanists alive to the future of their subject should read. British botanists are talking over ways and means of bettering their teaching with a degree of criticism and candor hopeful for significant reforms.

It is a discussion that should result in an attempt to modify elementary teaching in such a manner that certain material, some of it quite new to prevailing practise but believed to be of fundamental importance, shall find a place or adequate treatment in elementary courses. Since introductory courses can not be long courses certain subjects, some of them time honored, are brought into court to justify their value or to give way wholly or in part to the demands of the new.

The universities of the United States have this year been asked by the government to present in prescribed terms of twelve weeks a group of subjects for a very large body of men—the Student Army Training Corps. One of these is biology and in most cases the course is likely to be organized as of two subjects, botany and zoology, which, for practical reasons, will probably be treated in large measure apart from one another. Botany is, therefore, to be taught by a large number of instructors in courses that will approximate the equivalent of six or twelve weeks from nine to eighteen hours a week. The mental adjustments of the instructors to the pedagogical problems presented will be great, their reactions will be various. Compelled by the time limits to give a short course they must lay aside many a pet affection for this or that topic and practise a rigid selection of material to a degree never before demanded of them. There is certain to result from this large experiment a very considerable readjustment of values in the minds of those who organize the work. Botany after the war will not be taught in many institutions as it was before.

In the first place instructors will feel strongly the pressure to present practical aspects of the subject since their students are definitely fitting themselves for special fields of interest. There will not be time to develop in detail any of the great fields of botany, morphology, physiology or ecology. All that can be hoped is to give some understanding of plants as living things, with structure developed to accomplish certain results, with life habits adapted for certain ends, organisms that fit into a scheme of evolution subject to certain simple principles. Always in the mind of the teacher will be the desire to show how plant life works harm or renders service to man.

Since practical considerations are so largely to establish the ends toward which such a course will lead and to guide the lines along which the course is to be framed, and because the course must be short and the students will not in general have had much training in science, the problems of the selection of material and methods of treatment become tests of judgment more severe perhaps than any which ever before have been presented to teachers of biology.

Morphology obviously can not ask for much more than the opportunity to serve the requirements of physiology since a knowledge of structure is basic to an understanding of function and life processes. The study of comparative morphology with the end in view of developing phylogenetic relationships is clearly impossible in so short and condensed a course.

Physiology must content itself with simple considerations because the students will have had little training in physics and chemistry. General principles of plant physiology alone can be presented. Since the thought of the whole world is at present so largely centered on food problems the subjects of food elaboration and food storage should take a prominent place in the course.

Ecology has its part to perform but will be severely limited by the fact that extended acquaintance with groups of plants can not be given. It must rely chiefly on what general information the students may possess of forest, prairie, shrub and swamp vegetation, together with some elementary facts of physiography and geology.

Economic botany will make its demands wherever in the course appropriate connections can be made. Its importance is evident but it can hardly hope for much opportunity of consecutive treatment.

Of direct interest will be some of the lower plants in their relation to the subjects of sanitation, hygiene, fermentation, decay and to disease.

Finally such a course will miss an end, if the student fails to comprehend some of the simpler principles of organic evolution and the fundamental biological deductions which have so profoundly affected philosophy.

This is the general nature of the course to be tried out in our numerous institutions of higher education, and it seems not unreasonable to hope that the experiment may bring about a certain amount of agreement in the profession as to what may constitute the best introductory course in botany. Some possible results of the experiment and the discussions that formally or informally will come out may be briefly outlined.

Is it not probable that comparative morphology, based on type studies and having for its end the outlining of evolutionary relationships between the great groups of plants, must give way in introductory treatments and work out its ends through courses that will follow? Physiology and ecology in simple form may take a more prominent place, especially as they bear on such practical subjects as agriculture, forestry, etc. Fundamental principles of genetics for the same reasons will call for attention besides having their obvious connection with broad biological principles. Evolution may be treated not so much as a record of past accomplishments in phylogenetic history but with respect to the manner through which it is ever working. Economic botany seems certain to make important demand on the content of an introductory course.

Comparative morphology needs no advocate of its value and interest. Its followers may feel confident in the security of its position in botany. Those who teach it know that satisfactory results are not obtained when the subject is crowded for time. There are no short cuts to an understanding of morphological relationships. The basis of study must be detailed and thorough laboratory work. It is a fair question whether comparative morphology will not find greater satisfaction and obtain better results unfettered from the time limitations of the crowded introductory course with its necessarily mixed topics.

Morphology, physiology, ecology, genetics and the long list of special botanical subjects—none of them can hope to build upon an introductory course with any considerable degree of security. Each must construct its program according to its own special requirements frequently dependent upon other subjects or sciences. Physiology rests upon physics and chemistry; genetics makes use of mathematics; all special lines of botany require to some degree a knowledge of morphology.

Under these conditions will not the introductory course come more and more strongly to stand out as one that attempts nothing more than the grounding of fundamental principles and a selection of information with rather definite reference to its general and practical interests, or its broad philosophical bearing?

BRADLEY MOORE DAVIS

WASHINGTON,
November, 1918

A POSSIBLE NEW FUNGICIDE FOR WHEAT AND BARLEY SMUT

THE eradiction of stinking smut from wheat grown on the Pacific coast appears to be contingent upon the prevention of reinfection of treated seed by spores of smut in the soil or upon its surface. Even though the wheat farmer may have a smut free field, his soil is subject to infection by smut showers from his neighbors who thresh and blow into the air myriads of smut spores which are carried for miles by the winds.

Formaldehyde treatment for stinking smut in seed wheat, which has been found so effective and cheap in the states east of the Rocky Mountains where soil infection apparently does not occur, is ineffective against smut infected soils everywhere. This is due to the immediate evaporation of formaldehyde gas when the solution dries from the seed.

On the Pacific coast, wheat farmers have generally found that bluestone-treated seed escapes wholly or in part from soil infection. Bluestone solutions (1 pound to 4 or 5 gallons of water) are so strong that heavy loss in seed germination occurs. To prevent this loss, the bluestoned seed is dipped in a lime solution. This double dipping adds considerably to the cost and labor concerned in the seed treating process. Inquiries are frequently received requesting to know if the lime can not be mixed with the bluestone and but one dipping given. As the lime counteracts the effects of bluestone on smut spores, this process is not advisable.

In devising some means to meet the situation the writer devised tests using the lime sulphur-dip so universally used in spraying fruit trees for fungous pests. Preliminary tests with wheat and barley show the lime sulphur-dip at rather dilute solutions to be very effective against both stinking smut of wheat and covered smut of barley. As a thick coating of the dip adheres to the seed, it is quite effective against soil infection. The germ of seed wheat and barley dipped in a lime-sulphur solution even as strong as one part to one part of water gave, in these preliminary tests, no noticable deleterious effects on seed germination. If further more exhaustive tests confirm the preliminary ones, a fungicide which is much cheaper than bluestone and entirely lacking in destructiveness to the seed germ will have been secured.

W. W. Mackie
University of California,
Berkeley, Cal.

SCIENTIFIC BOOKS

A Text-book of Mycology and Plant Pathology. By John W. Harshberger. P. Blakiston's Son & Co., 1012 Walnut St., Philadelphia, 1917. With 271 illustrations, vii + 779 pages.

Students as well as investigators in mycology and plant pathology will greatly welcome the appearance of the above named work, by Dr. Harshberger. This is perhaps the only American book of its kind which treats of mycology in its true relationship to plant pathology. The book is of special interest, as it is written by a man who combines the knowledge and the technique of the old and the young botanist. Dr. Harshberger's work is the result of twenty-seven years experience in teaching and in preparing men for the botanical profession.

Like all other of his works, Dr. Harshberger's present book is very exhaustive; indeed it may safely be called an encyclopedia of mycology and plant pathology. It contains a wealth of information all written in concise language. It is also abundantly illustrated, and the numerous references will be especially welcomed by students and investigators. A book of this nature should not be judged by some few imperfections, or errors, in spelling, but rather by its scope and its ability to cover the field in a precise way. In this the author seems to have succeeded.

The book is divided into four parts:

Part I. deals with systematic mycology. It is divided into twenty-one chapters in which the Myxomycetes, the Schizomycetes and the Eumycetes are considered at length. The Myxomycetes receive a considerable share of attention and emphasis is laid on the pathogenic forms. A complete bibliography is also appended. The discussion of the Schizomycetes is taken up in a similar fashion as the Myxomycetes. The pages dealing with the fungi are preceded by chapters on histology, chemistry, physiology, ecology, etc. A comprehensive treatment of enzymes in fungi is also given. The chapter on the geographic distribution of fungi will be appreciated by the plant pathologist. The distinctive features of the taxonomic chapters on the fungi is that emphasis is laid on the forms pathogenic to plants.

Part II. takes up a general consideration of plant pathology. The various forms of disease, the predisposing factors, the symptoms, etc., are very clearly set forth.

Part III. deals at first with a list of specific diseases of economic plants. These are taken up alphabetically and the reader is referred to a list of fairly extensive agricultural experiment station bulletins. The second part of

Part III. goes into detailed account of specific diseases of plants in which the hosts are also taken up alphabetically. Only those diseases which are of economic importance are considered. The doubtful ones, or those of little economic importance, are omitted. Here plant pathologists will find ground to differ with the author in his choice of those specific diseases which he considers most important. The survey in the chapter of non-parasitic, or physiologic, diseases will be appreciated by the student.

Part IV. takes up a detailed account of laboratory and teaching methods. Here the author incorporates much of his own methods and technique. This part will be found of particular interest to the teacher of both undergraduate and graduate students. Part IV. is made up of forty-six lessons in which every phase of laboratory technique is elaborately and clearly set forth. Finally the book concludes with an appendix which considers the preparation of fungicides and insecticides, spray calendar, keys for determining species of *Mucor, Aspergillus, Penicillium,* Erysiphaceæ and the fleshy fungi.

The distinctiveness of the book is the extensive field which it covers in mycology and plant pathology. It stands by itself, in its difference from the average American text-book bearing on these subjects. The book fills a timely want, and it should find a place in every library of the teacher, investigator or student.

J. J. TAUBENHAUS

TEXAS AGRICULTURAL EXPERIMENT STATION

THE ROYAL COLLEGE OF PHYSICIANS[1]

THE four hundredth anniversary of the foundation of the Royal College of Physicians of London is an event which can not be allowed to pass without comment. On September 23, 1518, Henry VIII. granted the charter by which the college was constituted. He did so, moved by the example of similar institutions in Italy and elsewhere, and by the instigation of Thomas Linacre and others of his own physicians, and of Wolsey his chancellor, with a view to the improvement and more orderly exercise of the art of physic, and the repression of irregular, unlearned and incompetent practitioners of that faculty. The college consisted of eight persons known as "elects," with power to elect from amongst themselves a President annually, and to choose the "most cunning and expert men" to fill vacancies as occurred in their number. At the same time it was enacted that no person except a graduate of Oxford or Cambridge, without dispensation, should be permitted to practise physics throughout England, unless he had previously been examined and approved by the president and three of the elects. The first meetings of the college were held at Linacre's private house in Knightrider Street, the front portions of which, comprising a parlor below and a chamber above, used as a council room and library, were given to the college during Linacre's lifetime. These small premises—the ground on which they stood only measuring about twenty-four square feet—continued to be used for nearly a hundred years. But in 1581 they were enlarged, and a capacious theater added, in which to deliver the lectures founded by Dr. Caldwell and Lord Lumley, in 1583. Dr. Foster was the first Lumleian lecturer. A botanical garden, under the supervision of Gerard, was also secured. Linacre, founder of the college, learned both as physician and scholar, was president until he died in 1524. Of distinguished successors and benefactors of the college during its first hundred years of existence the names of Clement (1544), professor of Greek at Oxford; of Wotton, the zoologist; of Caius (1555), linguist, critic, physician, naturalist, second founder of Gonville and Caius College, Cambridge, antiquarian and designer of the insignia of office still used by presidents; of William Gilbert (1600), author of "De Magnete" and first physicist of the college, naturally occur to us. The last meeting in the old college in Knightrider Street was on June 25, 1614; the first meeting in the new college, in Amen Corner, Paternoster Row, was on August 23, 1614. Here, in April, 1616, Harvey

[1] From the *British Medical Journal.*

delivered the Lumleian lectures in which he is supposed to have expounded his doctrine of the circulation of the blood; two years later the first Pharmacopæia Londinensis was issued by the college. The civil wars reduced the college to the greatest distress. Unable to pay an assessment by Parliament of five pounds per week, and its rent to St. Paul's, it was in danger of being sold by auction, when Dr. Baldwin Hamley came to the rescue, purchased house and garden himself, and with the utmost generosity presented them to his colleagues two years afterwards. Prosperity followed, for in 1653–4 the munificence of Harvey enriched the college with a museum, a "noble building of Roman architecture," stocked with valuable and curious contents, and a library of medical books, treatises on geometry, geography, astronomy, music, optics, natural history and travels. But this prosperity was not long continued. After Harvey's death in 1657, the treasury was nearly empty, lectures were suspended, large numbers of physicians were living and practising without a license within the liberty of the college, examinations were discontinued. The creation in 1664 by Sir Edward Alston of upwards of seventy honorary Fellows, both brought unlicensed practitioners under the authority of the college and replenished its coffers. But in 1665, during the great plague, most of the Fellows and officers of the college fled the city, and thieves broke in and stole the whole of the contents of the treasury chest. On September 5, 1666, the great fire consumed the whole of the college buildings; only the charters, annals, insignia, some instruments and portraits, and 140 printed books in the library were saved. The premises in Amen Corner were never rebuilt, and the college remained homeless until its new buildings in Warwick Lane, designed by Sir Christopher Wren, were opened without ceremony on May 13, 1674. This commodious and stately building occupied four sides of a quadrangle enclosing a large paved court, on the east side of which was erected at Sir John Cutler's expense a spacious anatomical theater. The other sides of the quadrangle contained the library, cœnaculum, censors' room and other public apartments. At the back of the college were the botanical garden, and in 1684 a noble library building was presented by the Marquess of Dorchester. Here the college stood for 150 years; all that remains of it now is the beautiful Spanish oak wainscoting, the gift of Hamley, which lines the Censors' Room in Pall Mall, and two colossal statues of Cutler and Charles II, which may be seen in the Guildhall Museum. At the end of 150 years the college buildings had become dilapidated, Warwick Lane was a slum, the population and fashion had moved westwards, and a more convenient situation for the Royal College of Physicians was a necessity. Mainly through the influence of Sir Henry Halford, a grant of land was obtained from the Crown at a cost of £6,000 in Pall Mall East, and on it the present college building, designed by Sir Robert Smirke, was erected and opened with great ceremony on June 25, 1825. The premises in Warwick Lane were sold for £9,000. One may regret their disappearance, and that it is no longer possible to people them with the shades of those who have made the history of medicine and of this famous college during 150 years of its life. The names of such are Mayerne, Glisson and Sydenham, exponents of clinical medicine, followed by Radcliffe, Garth, Arbuthnot, Freind, Sloane and Meade, and last but not least, William Heberden. All of these have made their mark in the history of medicine, and directly or indirectly have been associated with the history of the college. The quartercentenary of the Royal College of Physicians of London reminds us that, in spite of modern progress, we can not afford to neglect the learning of past ages.

SPECIAL ARTICLES

SUGGESTIONS REGARDING THE CAUSES OF BIOELECTRIC PHENOMENA

Bioelectric phenomena constitute a group of facts for which adequate and satisfactory explanations have hitherto been lacking. It is my purpose in this paper to point out certain

significant correlations between these phenomena and the metabolic gradients which are now known to exist in organisms; and to propose an explanation of the former in terms of these gradients. The metabolic gradients were first demonstrated by Child in *Planaria;* subsequently he and his students extended the observations to include a large number of adult organisms, cells and embryos.[1] This work has shown that the anterior, oral or apical end of organisms has the highest metabolic rate and that this rate decreases along the sagittal axis. A gradient in rate of metabolism therefore exists along this axis; and to a less extent along other axis of symmetry also. This fundamental discovery has furnished a basis for the interpretation of many hitherto entirely inexplicable biological facts,[2] and I believe that it also throws light upon the nature of the bioelectric currents.

The term metabolism is too well understood to require definition; it commonly signifies the sum of chemical processes which results in the production of new protoplasm or other organic compounds, or of energy. "Metabolic rate" simply means the rate at which these processes take place; and modern chemistry, particularly through the study of organic and other catalyzers, has taught us the supreme importance of rate in any chemical system. The metabolic rate is generally measured either by the rate at which the raw materials, particularly oxygen, for the reactions are used up; or by the rate of production of end-products, especially carbon dioxide. The extent to which a given mass of protoplasm is actually alive is determined by its metabolic rate; these chemical reactions, always building and destroying, are the very essence of the living; when they sink to a rate so low that only the most delicate means serve to detect them, the organism is practically lifeless, but when they burn intensely, the most marvelous manifestations of protoplasm, such as thought, leap forth.[3]

The following suggestions are by no means entirely new; similar ones have already been made by Waller, Child and Tashiro.[4] In collaboration with Mr. A. W. Bellamy of this laboratory, I am collecting further data upon these matters, and the complete results, together with a more extended discussion of the literature, will appear later; but a sufficient number of facts are already known to justify a preliminary statement of the relation between metabolic conditions and differences of potential found in organisms.

1. *Permanent Differences in Potential.*—In a number of cases we know both the metabolic gradient and the permanent differences of electrical potential along the antero-posterior axis. Thus Mathews[5] in 1903 discovered that the head of hydroids is electro-negative to the stem, and that anterior levels are electronegative to posterior ones. Later, Child[6] demonstrated that in these animals the head or any anterior level has a higher metabolic rate than any posterior level.[7] Hyde[8] found

[1] Child, "Individuality in Organisms," Univ. of Chicago Press, 1915.

[2] Child, *Jr. of Morph.*, XXVIII., p. 65; XXX., p. 1; *Roux's Archiv*, XXXVII., p. 136; Newman, *Biol. Bull.*, XXXII., p. 314, are a few examples where such interpretation has been applied.

[3] Alexander and Cserna, *Biochem. Zeitsch.*, LIII., p. 106, have demonstrated that the oxygen consumption of the brain greatly exceeds that of any other part of the body.

[4] Child, "Individuality in Organisms," p. 63; Tashiro, "A Chemical Sign of Life," Univ. of Chicago Press, 1917; Waller, "Signs of Life from their Electrical Aspect," London, 1903.

[5] *Am. Jr. of Physiol.*, VIII., p. 294.

[6] SCIENCE, XXXIX., No. 993.

[7] An additional statement regarding the metabolic gradient in hydroids would seem to be required owing to the recent paper of Garcia-Banus (*Jr. Exp. Zool.*, XXVI., p. 265), who states that apical pieces of the stem of Tubularia do not regenerate oral hydranths faster than basal pieces. In the summer of 1914 at Woods Hole, while I was a student in Professor R. S. Lillie's class in physiology, I performed this experiment with the common tubularian hydroid found there, called at that time *Parypha.* I found the hydranths arising earlier on the apical pieces; the result was clear-cut and definite. The experiment has since been repeated at Woods Hole to my personal knowledge with the same result as mine. Driesch also (*Roux's Archiv*, IX., p. 130) found that oral

that the animal pole of turtle and other vertebrate eggs is electronegative to the vegetal pole, and the anterior ends of vertebrate embryos electronegative to posterior regions. Child[9] subsequently found in similar materials that the electronegative regions are also regions of high metabolic rate. Morgan and Dimon[10] reported that the anterior and posterior ends of *Lumbricus terrestris* and *Allolobophora* (*Helodrilus*) *fœtida* are electronegative to the middle. Mr. Bellamy has repeated this experiment and confirmed the result on *Helodrilus caliginosus*. In my work on the aquatic oligochætes,[11] I was able to show in a number of species that the anterior and posterior ends have a higher metabolic rate than the middle. The same state of affairs presumably exists in the terrestrial oligochætes also, although these can not be tested by the available methods for demonstrating differences in metabolic rate.

In these cases the regions of high metabolic rate are always permanently electronegative to regions of lower metabolic rate. This fact suggests the hypothesis that the metabolic differences are directly responsible for the differences in potential and that the latter are, therefore, of chemical origin. This is also the opinion of Child, and R. S. Lillie has recently come to a similar conclusion.[12] I am also in accord with R. S. Lillie regarding the chemical process which is at the bottom of these differences in potential,—namely, that it is an oxidation and reduction phenomenon. In considering this matter, one must remember that when one states that a given region is electronegative, one means electronegative with respect to the galvanometer, exactly as one says that the zinc pole of a cell is the negative pole; actually the zinc pole is positive to the carbon or copper pole, and similarly the regions of high metabolic rate are in reality electropositive to regions of lower metabolic rate. If one considers now the familiar "action at a distance" experiment of chemistry, in which the oxidation is carried out in one beaker, and the reduction in another, one finds the electrical conditions thus produced to be identical with those observable in organisms. The current runs in the galvanometer from the reduction beaker to the oxidation beaker, and in the bridge of salt solution from the oxidation beaker to the reduction beaker. The region of oxidation is thus, as also in the region of high metabolic rate in the organism, electronegative galvanometrically, actually electropositive. We have abundant evidence that the metabolic gradient runs parallel to the rate of oxidation. In the organism, however, oxidation and reduction are not separated as in our experiment, but there in all probability, the electric difference of potential is due to difference in rate of oxidation at difference levels,—in other words, to a concentration cell with respect to oxidation.

2. *The Current of Injury*.—It has long been known that any cut or injured surface is electronegative (galvanometrically as explained above) to intact surfaces. In this laboratory we have frequently observed that such injured surfaces always have a higher metabolic rate

hydranths appear earlier on apical than on basal pieces. In animals so lowly organized as the hydroids, where the metabolic gradient is well marked only near the apical end, practically lacking near the base, and very plastic and readily alterable by external factors, it is easy to select conditions under which the basal pieces will regenerate hydranths as fast as or faster than the oral ones; such conditions are: using long pieces, taking pieces from the more basal regions of the stem instead of from the apical regions, using basal pieces near the place where a branch is about to form, slight depressing conditions, etc. (the mere fact that pieces do well in the laboratory is not evidence that no depression existed; in fact, depressed pieces are more likely to survive than vigorous ones). Since Garcia-Banus mentions none of these factors in his paper, not even stating *whether his apical pieces are near the original hydranth or not*, it is presumable that he failed to control or eliminate them, and that this explains why he was unable to obtain the same results as other investigators.

8 *Am. Jr. of Physiol.*, XII., p. 241.

9 This work is largely unpublished. See, however, on amphibian embryos, Child, *Roux's Archiv*, XXXVII., p. 135.

10 *Jr. Exp. Zool.*, I., p. 331.

11 *Jr. Exp. Zool.*, XX., p. 99.

12 *Biol. Bull.*, XXXIII., p. 181 ff.

than uninjured regions, as determined by our methods; and further that this increase in metabolic rate is the result of the stimulation of cutting, since it does not occur if the cutting is done under anesthesia. We have also shown that this alteration of metabolic rate as the consequence of injury occurs not only at the cut surface but involves adjacent uninjured regions also, in proportion to their distance from the cut. Tashiro[13] has further found that injury invariably increases the carbon dioxide output of living material, and he believes this reaction to injury to be an infallible sign that the material is living.

In the text-books of physiology, explanations of the current of injury are usually based upon supposed alterations of membranes, concentrations of electrolytes, etc., at the cut surfaces,—that is, the cut place is supposed to cause the phenomenon. But our observations show that the change in metabolic rate occurs not only at the cut surface but for some distance away from it; and an experiment of Bose[14] demonstrates that the region of electronegativity also exists not merely at the site of injury but for a considerable distance away, diminishing in fact with distance. Here again the current runs parallel with the metabolic conditions at and near the injured regions. Bose concluded that the actual injury to the cells is not directly the cause of the electronegativity but that the stimulation due to the injury produces the electric change; and this stimulation, like many others, is transmitted with a decrement to surrounding regions. Injury is thus a form of stimulation and our experiments and those of Tashiro show that the stimulation of injury produces in the organism an increase in metabolic rate. Hence, as in the preceding case, we may suggest that the current of injury arises through the fact that the site of injury and adjacent regions are regions of increased metabolic rate and thus are electronegative to intact regions, where the rate is lower.

3. *The Current of Action.*—Whenever any living material is "stimulated," the stimulated region becomes *ipso facto* a region of electronegativity with respect to non-stimulated areas. In order to analyze this universal phenomenon, it is necessary to know what the nature of stimulation is. Physiologists are still very far from a solution of this difficult and fundamental problem. I venture to suggest, however, that everything that we know about stimulation indicates that increase in metabolic rate is its principal characteristic. Thus the oxygen consumption increases, the carbon dioxide output increases, the production of synthesized materials and of waste products is accelerated, the energy produced is augmented.[15] Tashiro,[16] for instance, after testing various kinds of plant and animal tissues, says: "In all cases stimulation causes an increase in carbon dioxide. We could never find any response unaccompanied by an outburst in carbon dioxide."

Every cell carries on a specific kind of metabolism, resulting in specific end products. As far as we know, each cell is always producing these whether it is in a stimulated condition or not, and the rate at which it does this is a measure of the degree to which it is alive. Thus Tashiro finds that all living substances give off carbon dioxide, and the rate of this output runs parallel to other manifestations of life, as relative irritability, rapidity of response, rate of conduction, etc. Let us consider very briefly the three chief active tissues of the body,—gland, muscle and nerve. In any particular kind of gland cell, barring special experimental or pathological conditions, there are in general the same kinds of granules to be found at all times. As far as one can determine, the rate of formation and discharge of granules alone is variable,—not their content. The essential effect of stimulating the gland cell through its nerve is an increase

[13] A chemical sign of life.

[14] "Comparative Electro-physiology," 1907, pp. 154 ff. Bose has a great deal of interesting experimentation on the bioelectric currents but unfortunately it is often very difficult to grasp his exact meaning.

[15] These statements can be verified in any of the recent text-books of physiology as Bayliss, Howell, Stewart, etc.

[16] *Loc. cit.*, p. 99.

in the rate of production of its secretion. As is well known, this stimulatory increase in secretory products is always accompanied by large increases in the amount of oxygen consumed, CO_2 produced and heat evolved. In the case of muscle, the amount of lactic acid produced furnishes a certain criterion of the metabolic rate of the muscle. In the resting state, the lactic acid content is small; after the stimulation of injury and after contraction, it is greatly increased. And although molecular oxygen does not appear to be consumed in this process, the production of lactic acid from carbohydrates is nevertheless chemically an oxidation. In nerve, where it was long believed that no increase in metabolism occurred during the passage of the impulse, it is now known, thanks to the researches of Tashiro,[17] that a relatively great increase in carbon dioxide output is associated with the process. He also presents some evidence that the oxygen consumption is likewise accelerated, during the conduction. In this connection it may be mentioned that Alexander and Revesz[18] found that the oxygen consumption and the carbon dioxide elimination of the brain are increased when the retina is stimulated by light. In nervous, as in other tissues, the difference between the resting and the stimulated state is then largely quantitative. Further significant facts are that the rate of the passage of the current of action along the nerve bears a direct relation to the known irritability of the nerve and the rate at which it conducts the impulse; and as Tashiro's work shows that these factors are also directly related to rate of carbon dioxide production (more irritable nerves in the resting state giving off more of the gas than the less irritable ones), it becomes obvious that metabolic condition is the primary factor in the causation of the current of action.

The evidence then clearly indicates that each cell is always carrying on a specific kind of metabolism and that stimulation consists essentially in the temporary acceleration of the rate of metabolism. From this point of view regarding the nature of stimulation, the current of action is readily explicable. Any stimulated region is a region whose metabolic rate has been temporarily increased by the stimulation, and as in the preceding cases, it must necessarily form with non-stimulated regions of lower rate a concentration cell with respect to rate of metabolism. It must therefore be electronegative to such non-stimulated regions. The various kinds of bioelectric currents are thus conceived as referable to the same cause, differences in metabolic rate; and they are, apparently, merely the consequence of such differences, and of no significance in themselves.

This explanation of the current of action has been long held by Waller (*loc. cit.*), who on scanty and indirect evidence and in the face of skepticism from other physiologists maintained that the metabolism of nerves is the same as that of other protoplasm, that the current of action is due to sudden increase in their rate of metabolism, and that this current is merely a sign of that metabolic change. Waller's idea has received strong confirmation through Tashiro's work.

Certain interesting corollaries follow if this conception of the nature of stimulation is true. Thus if an increase in metabolic rate is the essential feature of stimulation, it follows that any organ or cell whose rate of metabolism is already sufficiently high will function without stimulation—in other words, it will be automatic. Some physiologists deny that there are any truly automatic organs, but surely the facts that are known about the heart, the medullary centers, and the digestive tract sufficiently prove that automaticity is a real phenomenon. Consider, for instance, the embryonic heart, which in all known cases, has a beat of myogenic origin. The metabolic rate of this young muscle tissue is in all probability so high that it contracts in the absence of stimulation from without. Later, as the rate falls with age, the aid of the nervous system must be evoked to keep the apparatus going. The nervous system is, indeed, the automatic structure *par excellence* of the body and,

[17] *Loc. cit.*, Chaps. II. and III., also p. 53.

[18] *Biochem. Zeitsch.*, XLIV., p. 95.

as our conception demands, it is characterized by an exceedingly high rate of metabolism. This is demonstrated not only by its blood supply, its great susceptibility to lack of oxygen, to anesthesia, to cyanide and other poisons, but also by direct measurements of its rate of oxygen consumption. Thus, Alexander and Cserna[19] find that the oxygen consumption of the brain is vastly greater than that of equal weights of any other organs, and MacArthur and Jones[20] that the cerebrum and cerebellum respire faster than any other parts of the central nervous system, the rate decreasing gradually from these parts posteriorly. The nervous system by virtue of its intrinsically high metabolic rate is able to control other parts of the body, and to increase their metabolic rates by sending impulses along the nerves.

It should be mentioned that stimulation is characterized not only by the acceleration of the metabolic processes but also by other changes, which may well be the consequences of this acceleration, such as alteration of the colloidal state (probably in the direction of liquefaction), increase in permeability, and other effects.

4. *Galvanotaxis.*—The metabolic gradient also furnishes us with a logical explanation of the phenomena of galvanotaxis. It is well known that many animals when placed in an electric current will turn their anterior ends toward the cathode and travel to the cathode, maintaining such an orientation. Now as I pointed out in the first section of this paper, the anterior ends of a variety of organisms have been shown to have a higher metabolic rate than other parts of the body and to be electropositive (internally) to other parts. Since then the anterior end is positively charged or at least possesses the properties of an anode, it must when placed in the current be directed toward the cathode and it will tend to travel towards the cathode like any other positively charged material. Animals on the same basis might also travel backwards to the anode. Galvanotaxis is then a real taxis, or forced orientation, in the sense of Loeb. A crucial test of this hypothesis can be made upon the oligochaete worms, where, as we know from experiment, there are two regions of high metabolic rate and of electropositivity, —namely, the anterior and posterior ends. These animals should then when placed in a current bend themselves into a U-shape, head and posterior end directed towards the cathode, and middle towards the anode, and travel to the anode maintaining such a posture. This is exactly what they do as first pointed out by Moore and Kellogg[21] and since confirmed by Mr. Bellamy.

5. *Other Electric Phenomena.*—Since regions of high metabolic rate are electropositive (internally) to regions of lower metabolic rate, it follows that if any region can be made electropositive by running a current through it, that region must then have its metabolic processes accelerated and must thereby be stimulated, must become more irritable. That this is true is a familiar fact in electrophysiology. A constant current stimulates at the cathode when the current is made—that is, the region around the cathode becomes positively charged (or possibly becomes an anode in some other way), and hence has a higher metabolic rate, and serves as the source of the response. Similarly on the break of the current, the area of stimulation is that surrounding the anode, it having been shown that on the break the anode is really temporarily a cathode. Electrotonus is the same phenomenon. After prolonged passage of the electric current through a tissue, a large region around the cathode becomes excessively irritable because it is full of positively charged particles,[22] and a large region around the

19 *Biochem. Zeitsch.*, LIII., p. 106.

20 *Jr. of Biol. Chem.*, XXXII., p. 259.

21 *Biol. Bull.*, XXX., p. 131.

22 I do not wish to be understood as stating positively that the electrical sign of various parts of the organism is actually due to their containing free particles of that sign. This seems the most convenient way of putting the matter but the facts in themselves do not serve to determine whether the charge is on the inside or on the surface or indeed what condition is responsible for it. The facts of electrotonus would seem to favor the idea that the charged particles are inside.

anode loses its irritability because it is negatively charged.

A detailed report of the experiments which we are conducting on galvanotaxis and electrical gradients in organisms will, of course, appear elsewhere.

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THE AMERICAN MATHEMATICAL SOCIETY

The two-hundredth regular meeting of the society was held at Columbia University on Saturday, October 26, 1918. War conditions were reflected in an attendance of only eleven members. Professor E. W. Brown, of Yale University, presided at the morning session, and Professor O. E. Glenn, of the University of Pennsylvania, at the afternoon session. The following new members were elected: Professor R. A. Arms, Juniata College; Professor M. D. Earle, Furman University; Professor Ernest Flammer, Queen's University; Professor Gillie A. Larew, Randolph-Macon Woman's College; Dr. Flora E. LeStourgeon, University of Chicago; Professor John Matheson, Queen's University; Mr. F. R. Morris, University of California; Professor Susan M. Rambo, Smith College; Dr. W. G. Simon, Adelbert College. One application for membership was received.

A list of nominations for officers and other members of the Council was prepared and ordered printed on the ballot for the annual election in December. A committee was appointed to audit the accounts of the Treasurer for the current year. A committee was also formed to collect funds for a suitable memorial to the late Professor Maxime Bôcher, of Harvard University, who was president of the society in 1909–1910.

The following papers were read at this meeting:

J. E. McAtee: "The transformation of a regular group into its conjoint."

E. W. Chittenden: "On the Heine-Borel property in the theory of abstract sets."

G. A. Larew: "Necessary conditions for the problem of Mayer in the calculus of variations."

D. M. Y. Sommerville: "Quadratic systems of circles in non-euclidean geometry."

M. B. Porter: "Derivativeless continuous functions."

G. H. Hallett, Jr.: "Concerning the definition of a simple continuous arc."

R. L. Moore: "A characterization of Jordan regions by properties having no reference to their boundaries."

R. L. Moore: "Concerning simple continuous curves."

Edward Kasner: "Fields of force and Monge equations."

It was decided to hold the annual meeting of the society at Chicago in the Christmas holidays. No eastern meeting will be held at that season. But members attending the Baltimore meeting of the American Association are invited to read their papers before Section A, after registering titles and abstracts with the Secretary of the Society for record in the report of the Chicago meeting.

The southwestern section will not hold its Thanksgiving meeting this year. The February, 1919, meeting of the society will also be omitted. A regular meeting will be held in New York on April 26. The official list of officers and members will not be published in 1919.

F. N. Cole,
Secretary

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